How the Hollow Ways Got their Form and Kept Them: 5000 Years of Hollow Ways at Tell al-Hawa

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The story of the hollow ways in the North Jazira began more than 5000 years ago, when the collective footprints of people walking to and from their fields, leading their animals to pasture, and travelling between sites became so numerous that they wore away the earth and left paths still visible today. This paper reviews the potential cultural and physical processes behind the formation of hollow ways in the North Jazira, and asks to what extent formation studies may be biased by differential preservation. Whilst taphonomic processes affect all sites and features, recent landscape developments have been particularly destructive to archaeological remains. Despite this, thousands of hollow ways remain, but the reasons why they are preserved have never been examined. In short, this paper explores how the hollow ways got their form and kept them.

Background to the research

In 1980, construction began on the Saddam Dam on the Tigris River at Eski Mosul, which was intended to be the largest dam in Iraq. The accompanying irrigation scheme ultimately covered 750 km^2 and the irrigation canals, developments, and ensuing multi-season cropping would drastically alter the face of the landscape. The Director-General of Antiquities and Museums (DGAM) designated the area a rescue zone, and archaeological teams were invited to participate in a programme of rescue work.

In particular, excavations took place at Tell al-Hawa, the largest tell in the rescue zone (Ball 1990a; 1990b; 1994; Ball et al. 1989). Initially as part of the Tell al-Hawa excavations, and later expanding into a larger project called the North Jazira Project, extensive survey work was undertaken throughout the irrigation zone from 1986 to 1990 (Wilkinson and Tucker 1995). In total, 184 sites were identified and recorded, as well as off-site scatters and features, including hollow ways (Figure 9.1). The project aimed to 'unravel the complex sequence of settlement, land use and communications that evolved within a modest-sized enclave of land' (Wilkinson and Tucker 1995: 1).

Hollow ways are long, linear features typically measuring 70–120 metres wide (Wilkinson *et al.* 2010); the longest (preserved) hollow way in the North Jazira is approximately 5 kilometres. Their remains can still be seen in the landscape today as either slightly indented channels, lines of vegetation or water, or as lines on satellite imagery and aerial photographs (Figure 9.2).

Although there has been interest in the hollow ways for over half a century (e.g., Buringh and Mudiriyat al-Buhuth wa-al-Mashari' al-Zira'iyah 1960; Poidebard 1934; van Liére and Lauffray 1954), it was Professor Wilkinson's research (2003, see also Wilkinson *et al.* 2010) that definitively proved that hollow ways are the result of movement rather than drainage as previously argued by McClellan and others (McClellan and Porter 1995; McClellan *et al.* 2000), supporting van Liére and Lauffray's earlier theories (1954/55). There are three types of hollow way in the North Jazira: those leading from settlements to surrounding agricultural fields, those continuing beyond the fields out to pastures, and long-distance hollow ways that connect sites (Ur 2010; Wilkinson 1993; 2003; see Figure 9.3).

Professor Wilkinson also led the first and only excavations of these features (Wilkinson et al. 2010), providing geomorphological evidence for hollow way formation. Three hollow ways around Tell Brak (numbered 40, 50, and 61) were selected and excavations established that they date back to at least the 3rd millennium BC (Wilkinson *et al.* 2010). Hollow way 40 is particularly valuable for understanding formation processes, since samples were collected from its profile for soil micromorphological analysis (Wilkinson *et al.* 2010). The lowest fill level of the hollow way contained poorly sorted gravel consistent with intermittent flows of water resulting from heavy rain causing run-off from the tell (Wilkinson *et al.* 2010: table I). This process would have helped carve the feature into the landscape. It also sped up an existing process of erosion caused by 'the frequent movement of thousands of domestic animals, plow teams, and travelers' (Wilkinson et al. 2010: 766). It is unknown how quickly these formation processes took place, but Digital Globe imagery on Google Earth, dated to 2009 and 2012, shows the potential appearance of a new hollow way on the lower town of the site of Carchemish, indicating that this process of formation could potentially occur within three years.

Methodology

This paper focuses on the hollow ways identified in the North Jazira Project Survey (NJS) (Wilkinson and

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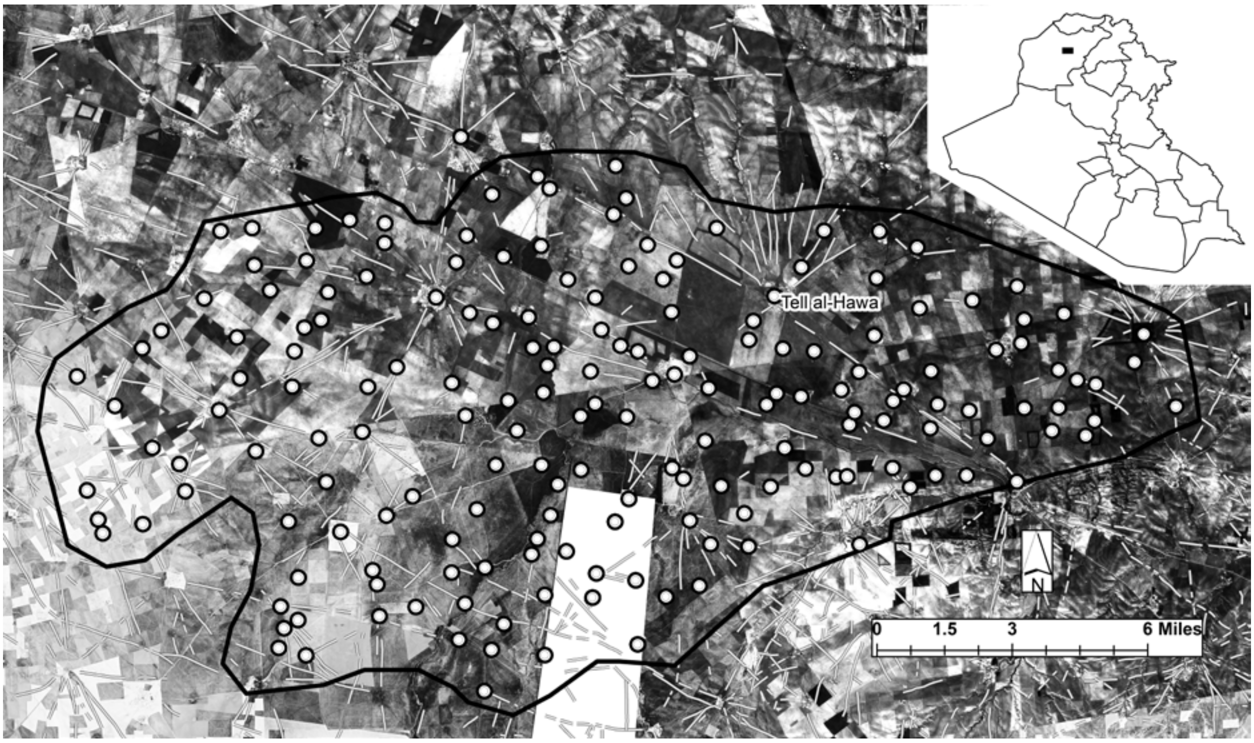

Figure 9.1. Map of the North Jazira Survey location, with sites identified (after Wilkinson and Tucker 1995) and the hollow ways, identified by Jason Ur, marked against 1102 and 1117 CORONA imagery.

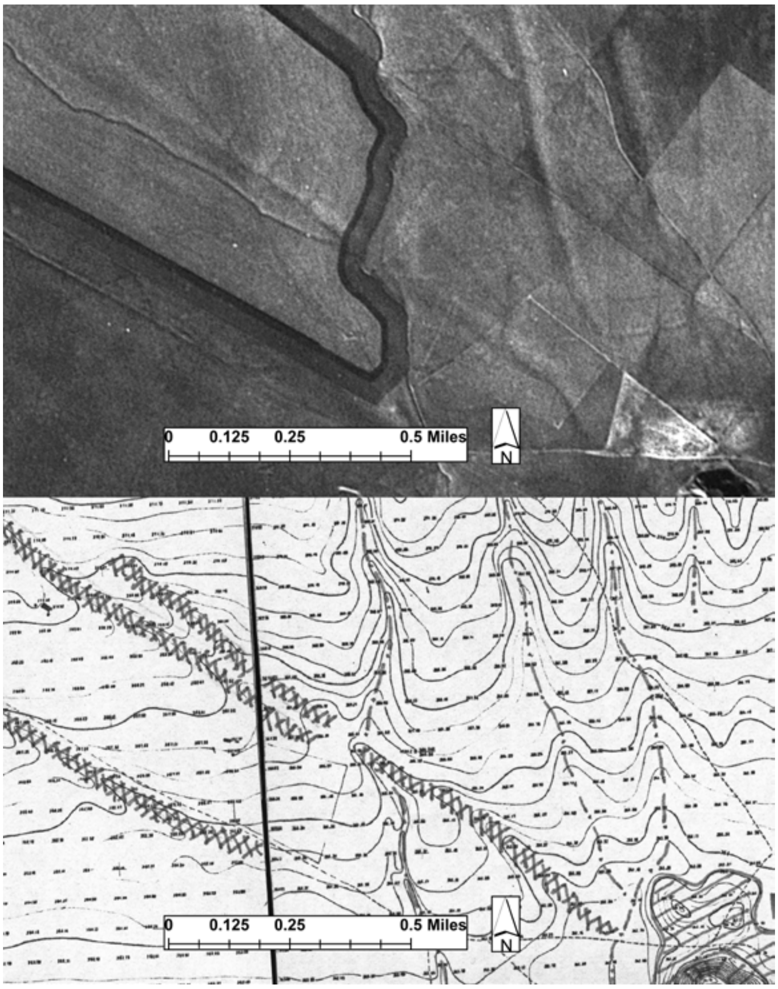

Figure 9.2. (Top) Sections of hollow ways to the west of Tell al-Hawa (in the bottom right corner) on 1102 CORONA. (Bottom) Contour map of the area: cross-hatching indicates hollow ways, whilst dashed-dotted lines indicate wadis.

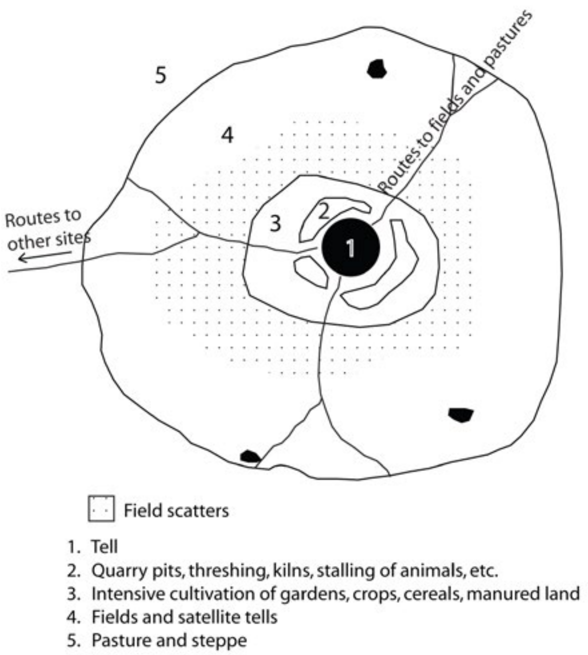

Figure 9.3. "Landscape of tells" based on Wilkinson (2003: 119, fig. 6.16). Schematic view based on field data.

Tucker 1995), particularly the long-distance hollow ways that connect early 3rd millennium BC (Ninevite V, circa 3000–2500 BC) sites[1] in the survey area. The initial work by Wilkinson and Tucker was further developed by Menze and Ur (Menze and Ur 2012; Ur 2003; 2010b; 2010a) when they mapped and created shapefiles of the hollow ways of the entire Jazira in ArcGIS using a combination of survey, aerial photography, and satellite imagery. Their data provides the foundation for the present study. We would particularly like to thank Dr Jason Ur for sharing his GIS data of the area (Figure 9.1). Cunliffe examined additional CORONA imagery, finding further hollow ways. Collectively, images from the the 1102, 1108 and 1117 CORONA missions were assessed (dating to December 11, 1967, December 6, 1969, and May 25, 1972, respectively). Shapefiles of the locations and extents of Ninevite V sites were selected for examination, as were the GIS maps of the hollow ways that connected the sites.

These CORONA images provide early views of the state of preservation of the archaeological features in the area. Additional snapshots over time are available on Google Earth, which hosts Digital Globe imagery from May 13, October 22, and December 16, 2004; from September 23, 2006, October 20, 2010; and a mosaic of SPOT imagery, the dates of which are uncertain (although Google Earth states the entire mosaic is from December 31, 2004, comparison to the SPOT archive suggests that this particular part of the mosaic dates to summer 2006). The analyses were supported by sub-metre contour data, which we are extremely fortunate to have.[2] Ultimately, three likely long-distance route ways were identified and selected for analysis: A, B and C, shown in Figure 9.4.

Examining why the hollow ways formed

The North Jazira is a largely flat landscape without any obvious physical constraints; therefore, movement between settlements was not constricted by the topography. While it is likely that plow teams respected the field boundaries of fellow farmers (Ur 2009), and pastoralists driving their animals to the grazing grounds beyond would do the same; the question remains: what factors guided travellers' movements between settlements?

Based on crop yield and population density estimates (Wilkinson 1990), settlements during the early 3rd millennium BC were not so closely placed that the fields of one abutted the fields of the next (see Figure 9.5). Travellers could move freely beyond the fields and yet they chose to walk in each other's footsteps with enough regularity that their footprints collectively carved the long linear hollow ways we observe today. It is possible to evaluate the effort needed to travel along potential routes, using cost analyses in ArcGIS and GRASS. As part of her doctoral research, de Gruchy developed a new method that directly and quantitatively evaluates the constructed models against the preserved hollow ways or other known routes. Models were constructed for easiest, fastest, and shortest (distance) routes between sites factoring both slope and land cover. The land cover was carefully reconstructed with a new methodology de Gruchy developed that uses dated archaeobotanical

[1] More recently, Lupton (1996) has re-examined the periodisation of sites, and it will be necessary to re-examine the periodisation again in light of the results from the large Associated Regional Chronologies for the Near East (ARCANE) Project; however this is beyond the scope of the present paper. Instead it is assumed that Ninevite V pottery is reasonably iconic, such that Wilkinson and Tucker's (1995) initial assignments of sites to this specific period are unlikely to change.

[2] The North Jazira Survey was originally denied access to maps or photographs, but Professor Wilkinson visited a Dutch consultancy firm in Baghdad, who possessed aerial photos and a set of Chinese maps. He made traces of these for use in the field. It is possible (and even likely) that if the regime of the time had discovered him using such highly sensitive unauthorised geographical data he would have been arrested and potentially imprisoned. Shortly before the first Gulf War, the firm was required to burn documents — including the maps and photographs. Instead, they contacted Professor Wilkinson, who purchased them with £3,000 from the British Institute. He then ferried them via diplomatic pouch from Iraq to London, where he personally collected them. When copying them into one large and one small set, Professor Wilkinson was forced to cut up the maps to fit the limited reprographic machinery available at the time. They remained with the British Institute for many years but on the retirement of one of the members, Professor Wilkinson was offered the collection. Although the larger set of maps was lost, the aerial photographs and the smaller set remain, for which we are grateful. Extracts from the contour map can be seen in Figures 9.2 and 9.10.

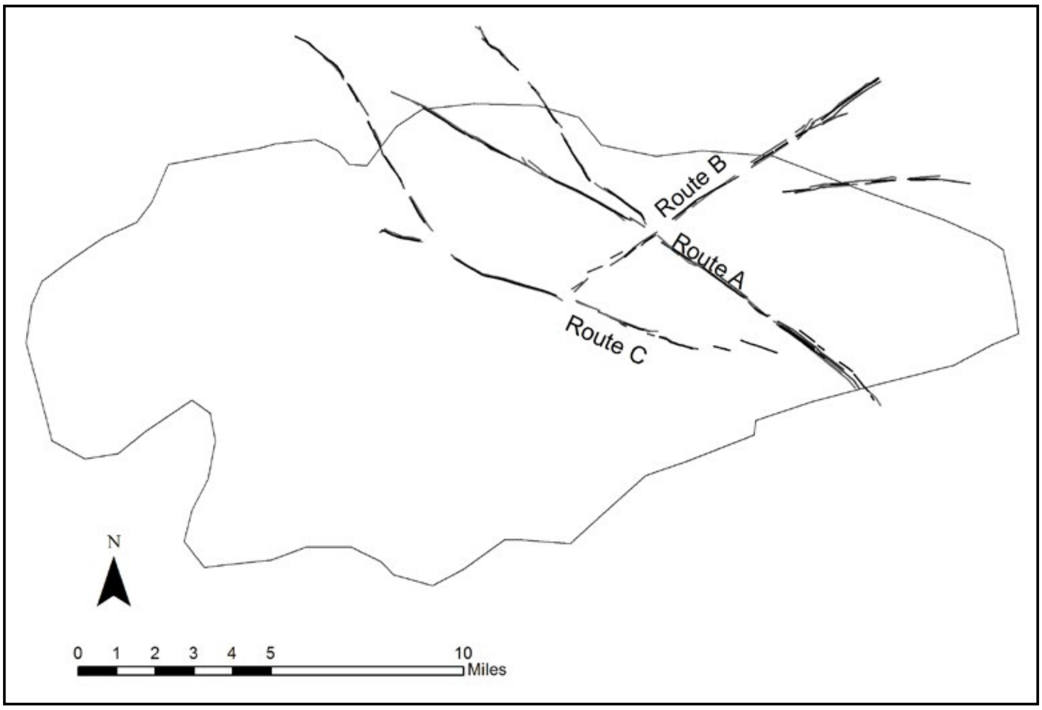

Figure 9.4. Third millennium routes mapped from the preserved hollow ways shown in relation to 3rd millennium sites identified by the North Jazira Project.

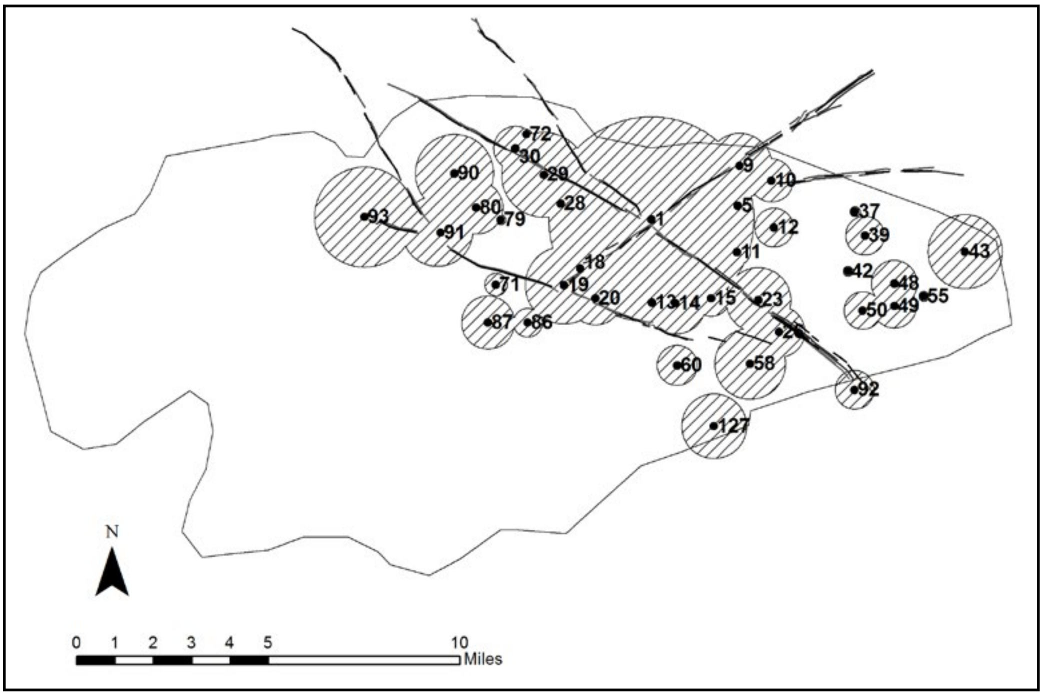

Figure 9.5. Map of the early 3rd millennium, Ninevite V, sites as identified in Wilkinson and Tucker (1995) with buffers representing field areas calculated based on values from Wilkinson (1990).

remains without any assumption that modern land cover in any way reflects what was there in the past (de Gruchy 2017; de Gruchy *et al.* 2016). For the fastest route model, the first velocity-based terrain coefficients were developed (de Gruchy *et al.* 2017), while existing energy-based terrain coefficients were used for the easiest route model (Givoni and Goldman 1971; Pandolf *et al.* 1977; Soule and Goldman 1972). Quantitatively assessing these models against the preserved hollow ways using either a 2-tailed Z-test, or bootstrapping, all three variables are statistically significant to the 90% level but, interestingly, the significance of all three physical variables lies in how little they match the hollow ways. Therefore no physical variable — easiest, fastest, or shortest routes — dictated how people moved through the landscape. Rather, their route choices must have been based on cultural factors.

Seeking permission from the headman

The distances between the larger early 3rd millennium centres in the North Jazira Survey area measure only 3 to 5 km or, at most, an hour's walk. In fact, the entire lengths of the longest routes, Routes A and C, could be walked in four hours; so there is no physical need for travellers (e.g., water, shelter for the night) to stop at any waypoints between any two destinations in the area. Yet, Wilkinson *et al.* (2010: 750) observed 'that the preserved hollow way segments do not run directly between these [al-Hawa, Hamoukar, and Tell Leilan] settlements, but rather extend between the cities and intermediate towns and villages.'

If there was no physical necessity to visit intermediary settlements, regardless of size, it may be that there was a cultural requirement. Tony Wilkinson and Graham Philip have both noted the need to visit local headmen in smaller villages during fieldwork, in Iraq and Syria respectively, in addition to obtaining permission from more senior authorities in larger centres (pers. comm. 2012–2013).

This requirement may have also been a factor in the past. Supporting this idea of needing to seek permission before travelling through a territory is the tablet ARET XIII 5 from Ebla, which is dated to just one hundred years after the end of the Ninevite V Period. Section 37 reads 'without my permission, no one can travel through my country, if you travel, you will not fulfill your oath, only when I say so, may they travel' (translation in Ristvet 2010: 3).

Testing this cultural variable should normally involve the comparison of two different models: The first model would draw routes between only the major sites along the long-distance hollow ways; the second model would draw routes between every site located along the long-distance hollow ways. Then, the two models would be compared quantitatively[3] against the preserved hollow ways. If the model of routes between only the major sites matched the hollow ways more closely, then it would be reasonable to conclude that travel was only between major centres where it is assumed head people would be located. If the model drawing routes between all the sites had the better results, then it would be reasonable to conclude that there was regular traffic between all sites, regardless of whether they were centres or small villages.[4]

However, in this case, the quantitative assessment was not necessary. An interesting, and obvious, pattern appeared once site size was mapped for early 3rd millennium sites in relation to the long distance hollow ways. The sites for the early 3rd millennium BC in the North Jazira Survey area fall into four distinct size categories: those up to 3 hectares in size, those which are 4–7 hectares in size, one site that is 10 hectares, and one site that is 42 hectares (see Table 9.1 and Figure 9.6). There are no sites that fall between these four categories and the first two categories appear to have normal distributions (see Table 9.2). Figure 9.7 displays the sites by size category in relation to the long distance hollow ways.

It is immediately apparent from Figure 9.7 that generally the smallest sites are located away from the hollow ways and the larger sites tend to be located on the long distance hollow ways. Also, the two largest sites are located on different, parallel long distance hollow ways. Therefore it appears, without any need for further modelling, that long distance movement during the early 3rd millennium does not include travel between the smallest sites (under 3 ha). Rather, any relevant authorities from which permission to travel was required were located only in the larger sites (those of 4 ha and over). Figure 9.8 is similar to Figure 9.7 except that it shows all of the hollow ways, not just those classified as long distance hollow ways. Interestingly, the smallest sites remain disconnected from the network with five exceptions: Sites 13, 18, 20, 30, and 92. It is unclear why these smallest of sites are located directly in the path of major long distance hollow ways. The published survey indicates nothing unusual or exceptional about them, but three of the five sites (13, 18, and 20) reach their maximum size during the Ninevite V Period. In contrast, most other sites of comparable size obtained their maximum extent in the

[3] The methodology for comparing route models to real world routes is detailed in de Gruchy 2016.
[4] In fact, this forms the general framework of what are actually four individual models, since a person needing permission may equally decide to take either the fastest or the shortest route to the headman. For this reason, it would be necessary to run both the models described with the fastest routes drawn between sites, then run both models again with the shortest routes drawn between sites and compare the results of all four.

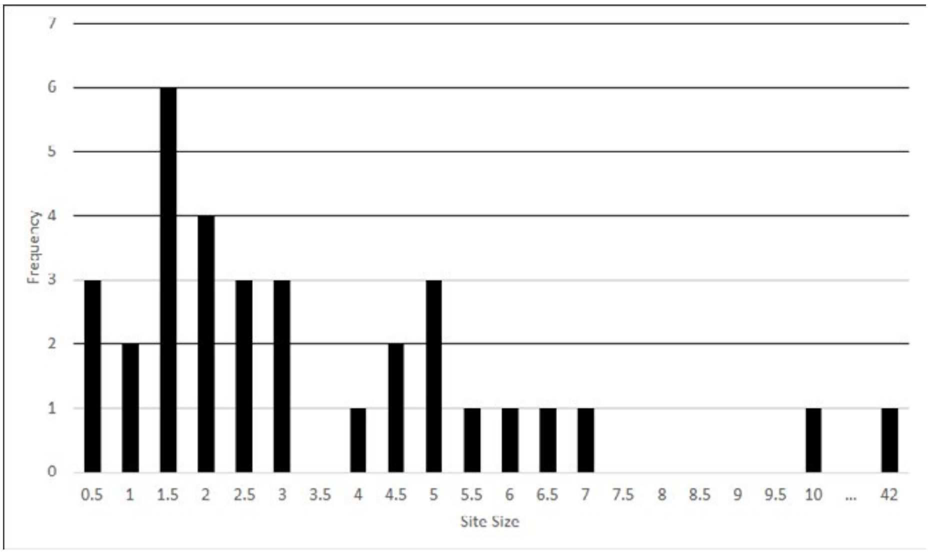

Figure 9.6. Histogram of Ninevite V site sizes, as presented in Wilkinson and Tucker 1995: Appendix C.

later 3rd millennium or Middle Bronze Age (Wilkinson and Tucker 1995: Appendix C).

Table 9.1. Site sizes by category in the North Jazira Survey.

Size (ha)	Number of Sites
0.5	3
1	2
1.5	6
2	4
2.5	3
3	3
3.5	0
4	1
4.5	2
5	3
5.5	1
6	1
6.5	1
7	1
7.5	0
8	0
8.5	0
9	0
9.5	0
10	1
...	0
42	1

Table 9.2. Descriptive statistics for sites in the up to 3 ha size category and the 4–7 ha size category.

Sites under 3 ha			Sites 4–7 ha	
Min.	0.4		Min.	3.8
Mean	1.6		Mean	5.2
Median	1.5		Median	5
Mode	1.5		Mode	5
Max.	2.8		Max.	7.2

This suggests that for whatever reason, these exceptional sites were an important part of the Ninevite V settlement network. Also, if the larger sites really are centres controlling tiny villages, then Thiessan Polygons (while not perfect) should provide some sense of what the territories of these centres looked like. Thiessan Polygons are created in ArcGIS through marking the separation of the space between sites. Lines are drawn at the mid-points between the sites to form the polygons. In this case the lines are drawn at the mid-points between centres (i.e., the larger sites), which are then assumed to be power centres in control of the smaller village sites. Looking at Figure 9.9, an interesting pattern emerges. Whenever a long-distance hollow way passes through a Thiessen polygon, it consistently runs through the centre associated with that polygon with only two exceptions. The first is the polygon associated with Site 43, which contains a hollow way that appears connected to the tiny village Site 10 and nothing else, possibly indicating the hollow way belongs to a different time period. The second exception is along the southernmost east–west route (Route C): here the Thiessen polygon associated with

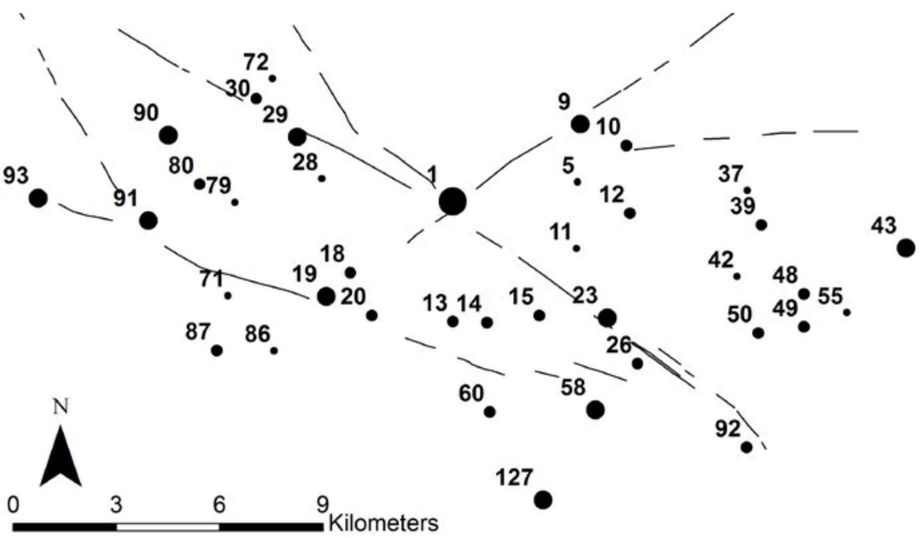

Figure 9.7. Sites mapped by size category in relation to the long distance hollow ways.

Site 14 covers the central portion of the route, while Site 14 itself does not appear to be directly on the route. Instead a hollow way connects Sites 20, 13, and 14, apparently deviating from the main route connecting Sites 19, 58, and 92. Finally, another pattern emerges: if a long-distance hollow way does not pass through a centre (Site 90), then it also does not pass through the associated polygon.

Returning to the polygon associated with Site 14, it is hypothesised that the hollow way segments that appear to form Route C, which connect Sites 20, 58, and 92, actually belong to a time period other than the early 3rd millennium. Instead, it is proposed that Route C originally ran between Sites 20, 13, 14, and 23, then down to Site 92, with a new route branching off from Site 23 to Sites 58 and 127. This would account for the discrepancy observed in the association between hollow ways and the Thiessen polygons of centres.

In order for this theory to hold, hollow ways would be needed where none were previously observed. In fact, an examination of new CORONA images identified possible additional hollow way segments running from Site 19 towards Site 14 and onward to Site 23; and further new potential segments from Sites 20 to 13 and 14. Unfortunately, a modern road runs between Site 14 and Site 23, so it is not possible to establish if there was a hollow way there or not. The other location checked for missing hollow ways was the area from Site 23 to Site 58, down to Site 127. There are many drainage channels and hollows running between Site 58 and Site 127, so it was difficult to be certain whether one of them was a hollow way, and nothing could be seen between Site 23 and Site 58. Nonetheless these newly identified segments do support the proposed path of Route C through Site 14.

The patterns observed suggest that the area of the North Jazira Survey, like the area around Tell Leilan (Schwartz 1989; 1994), is organised into complex chiefdoms with local centres that have control over the surrounding villages. The traffic to/from these villages is much lower, perhaps only the local villagers, and does not seem to leave any traces. Instead, most traffic is directly from centre to centre where, if permission does need to be gained, it is sought from the local chiefs in the centres and not in every little village. Writing about the later 3rd millennium BC, Ur (2009: 200–201) observes that it is the provincial elites who the ruler of Nagar (Tell Brak) was obliged to visit on his travels. Likewise, the Ebla tablet cited earlier (ARET XIII 5) is a treaty between Ebla and Abarsal — two centres, as opposed to a centre and a village. It is therefore particularly interesting to consider the polygon associated with Site 90. Why is this centre, and the associated territory predicted by the Thiessen polygons, avoided by the long-distance hollow ways?

The preservation bias

One possibility, already hinted at in the discovery of a previously unknown route section, is differential preservation. It may be that some routes appear absent as the evidence for them has been destroyed. If we can understand why some hollow ways remain while others are lost, we may be able to reconstruct past landscapes with greater accuracy, thereby improving our interpretations.

This part of the study used the previously selected route shapefiles for the three routes chosen and the site extent shapefiles determined by Ur (partially published here (Ur 2010b), but additional unpublished data was also supplied). Whilst survey data provided the 3rd

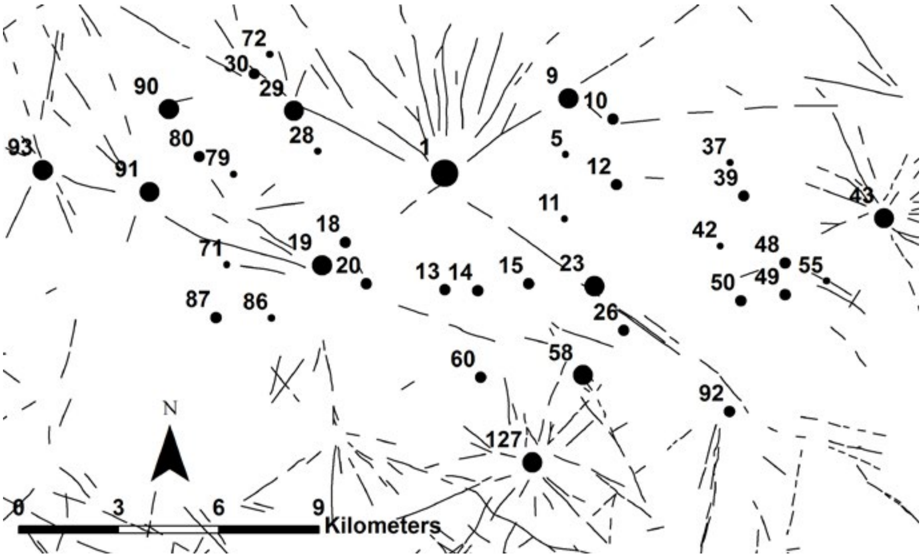

Figure 9.8. Sites mapped by size category in relation to all hollow ways.

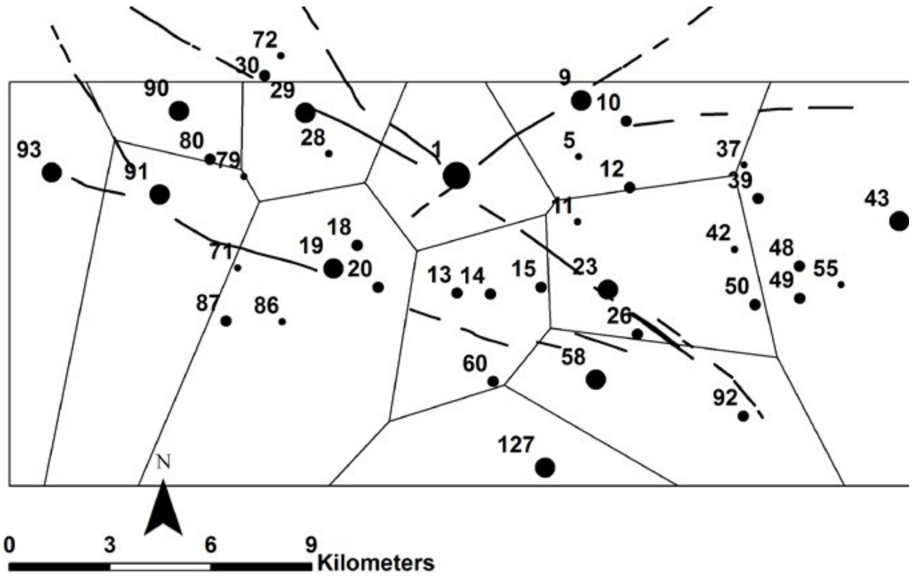

Figure 9.9. Thiessen polygons overlying sites mapped by size category and long-distance hollow ways.

millennium site areas, as indicated by pottery scatters for all sites (Wilkinson and Tucker 1995), the locations of the precise boundaries were not known. Therefore, the maximum possible site extent and potential boundaries were calculated from the visible extent on CORONA. All mapped routes either began or ended at a CORONA site boundary, or passed adjacent to one. The maximum possible original route length between settlements in the 3rd millennium was then estimated.[5] Ur had access

[5] Lengths of Routes A and B are calculated excluding maximum dimensions of Tell al-Hawa as calculated from CORONA, although this does not represent the size of the site during the Ninevite V period, when it was approximately 54% of the later obtained maximum size (77.1 ha versus 42 ha). The calculation of length for Route C on both the estimated original route length and the length of route remaining on Google Earth contains a segment of route between sites 19 and 20 that was identified by the authors during analysis of additional imagery unavailable to Ur. Since it was, however, presumably present as part of the original route, and is still visible on the Digital Globe image available on Google Earth (dated Oct 22, 2004) this length is also included in calculations. Finally, it should be noted that where Route A meets site 92, numerous parallel hollow ways were identified in the original survey work. Only one length has been used to calculate the original route, although it is acknowledged that multiple routes may have been in use, and the shortest route may not be correct. The

Table 9.3. Changes in amount of route remaining over time.

	Original Length (m)	Remaining length identified by Ur (m)		Remaining length identified on Google Earth (m)	
Route A	16590.26	11281.03	68%	8848.74	53%
Route B	7592.729	3689.92	49%	2572.94	34%
Route C	21424	10779.8	50%	3666.39	17%
Totals	45606.99	25750.75	56%	15088.07	33%

to some satellite imagery and aerial photographs that were unavailable in this study, so his data were also used to estimate the length of the routes remaining in the 1960s. The shapefiles were then imported into Google Earth, and the lengths of each route remaining in the 21st century were estimated (using the Digital Globe imagery) (Table 9.3).

The original research by Ur identified 19 route segments. A re-examination of these segments on Google Earth's imagery found only nine still remained. Of these, six were shorter, two were the same, and one segment was longer than previously thought. Route C is the least well preserved: today only 17% of it is left, compared to 53% of Route A. However, looking at all three routes, only a third of the original route network remains today. If this rate of attrition continues, the routes that were once a defining feature of the region will soon be lost. So what has affected their preservation?

Route use intensity

The first option to consider is whether routes that appeared to be used more (i.e., appear more deeply incised on imagery) were more likely to be preserved. As acknowledged by Wilkinson and Tucker (1995: 27) 'Although modern geographical theory postulates that interaction (i.e. traffic) between settlements should be proportional to the size of the settlements ... this cannot be assumed for the Bronze Age,' or any other age. Therefore, settlement size will not be considered here.

None of the remaining route segments are classified as 'broad' hollow ways, i.e., the wider hollow ways that are usually short radial routes from sites to fields and pasture. (The broad and narrow classifications are taken from Ur 2010, Map 2, and Wilkinson and Tucker 1995). Five were 'narrow,' and most likely older than the Islamic date often ascribed to them (see Wilkinson 1995: 54 versus Ur 2010). The remainders are unclassified.

length of segments remaining for this section is calculated using only the longest segment still visible in this area.

As the graph in Figure 9.10 shows, sites on some routes were occupied more frequently than sites on other routes, theoretically leading to deeper, wider, or more slowly infilled hollow ways that would leave clearer traces. However, while the four sites on Route B were the most frequently occupied, sites on Route A were the least frequently occupied, and yet still appear to be the best preserved, both in the 1960s and today.

Water erosion

Given the gradient of the Jazira, 5000 years of weathering could simply have eroded the routes. Contouring, taken from the Chinese maps obtained by Professor Wilkinson, shows the terrain is continuously sloping, and is therefore particularly susceptible to erosion. 'Because the land rarely slopes at gradients of less than 1:300, runoff can always be generated once the infiltration capacity of the soil has been exceeded. As a result, drainage concentration features (rills or wadis) can form everywhere, a crucial factor in the development of certain man-induced features such as hollow ways' (Wilkinson and Tucker 1995: 4).

All three routes will have conducted a certain amount of water as none of them are on a direct E–W line across the contour. Route B in particular runs NE–SW (downslope) and would potentially have been the most eroded by water flow. Certainly the hollow way segment between Site 9 and Site 1 was so deeply incised it was visible on contour maps (Figure 9.11), as was the segment between Site 91 and Site 19, amongst others. However, despite numerous periods of erratic rainfall, erosion is unlikely to be a major cause of feature incision. A wadi (visible on multiple CORONA satellite images, for example Figure 9.12) runs directly N–S past Site 9, and it and its drainage tributaries cross the deeply incised hollow way segment in several places, presumably channeling water away from the route. Another wadi is visible running parallel to segments of Route C (between Site 20 to Site 92), and also between Site 30 and Site 29 on Route A, so again, water was presumably conducted into the wadis, channeling the erosive sheetwash away from the hollow ways, limiting the erosional effect. This is not to say that erosion has

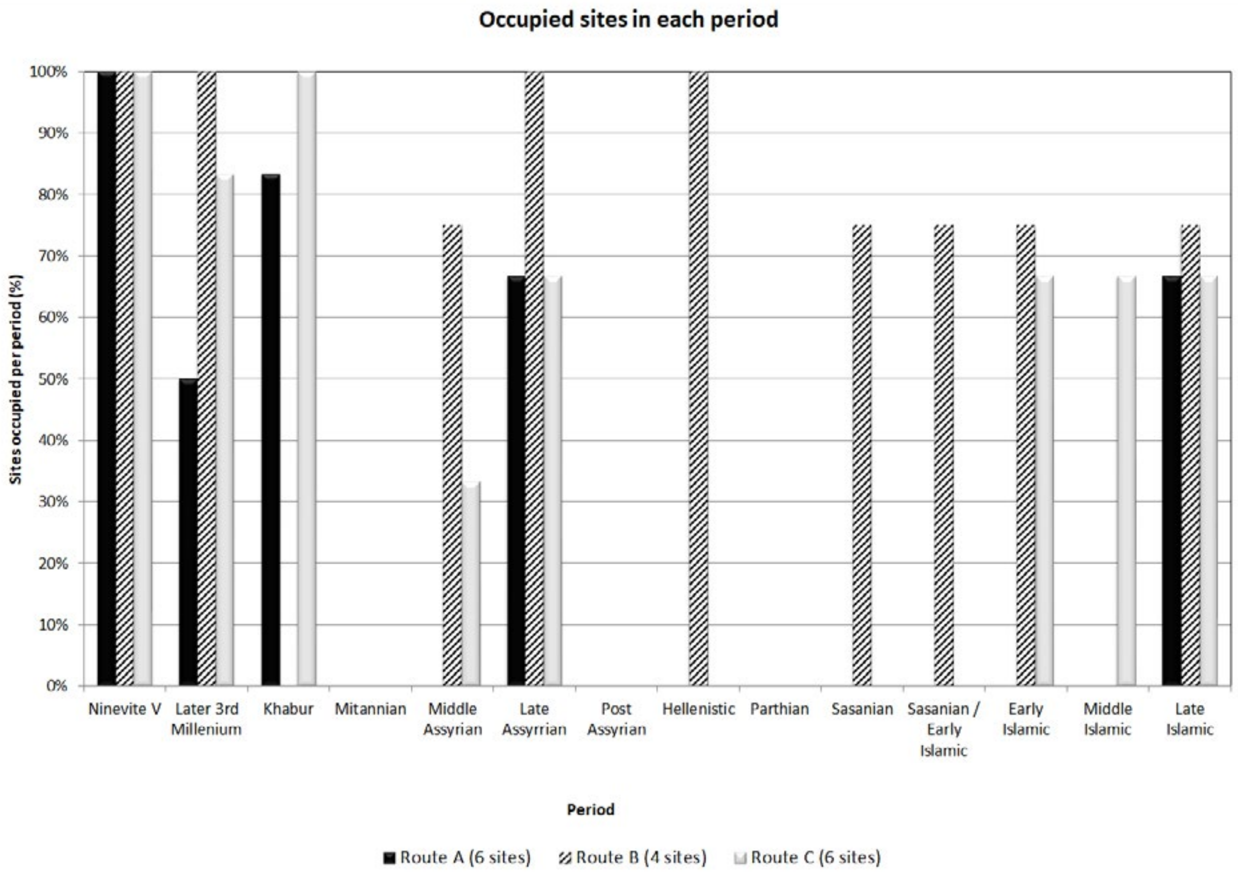

Figure 9.10. Percentage of sites on each route occupied in each period. Hashed lines indicate sites that have only trace occupations in each period. Chronology and occupation are taken from Wilkinson and Tucker 1995.

played no part, only that it is not the sole, most likely, or even main, contributor.

Modern effects

Recent human occupation is the most likely cause of feature loss. Major resettlement took place in the 1930s, encouraged by the British Mandate. By the time the aerial photographs and CORONA images used by Wilkinson, Ur, and others were taken in the 1950s and 1960s, the area had been resettled and turned to farmland. Even then, villages were fewer and smaller than during the 1980s when the al-Hawa survey work took place. Farmsteads lacked irrigated gardens, and fields were large and extensively fallowed. In 1970, the Jazira was considered to be largely composed of desert and to be particularly hard to irrigate, as water flowed in deeply incised valleys (Smith et al. 1971). Numerous wells were dug (and later drilled) to provide water, but by the mid-1980s much of the groundwater was no longer accessible through dug wells due to over pumping, and the drilled water was only suitable for animal husbandry or well-drained irrigation (Wilkinson and Tucker 1995).

In December 1983 the first stage of the massive Kirkuk (renamed Saddam) Irrigation Project was opened, followed in 1991 by a large supplemental irrigation project, the North Al-Jazira Irrigation Project, and the subsequent East Al-Jazira Irrigation Project. These were part of a scheme to ultimately irrigate 250,000 ha of the Al-Jazira plain. The plan, particularly the North Jazira Project, called for a linear-move sprinkler irrigation system utilising an extensive network of concrete lined canals, pipelines, feeder roads, agricultural complexes, new settlements, and massive mechanical irrigators. Together with the resulting irrigated multi-cropping, the landscape, and the archaeological sites it contained, were drastically altered (Ball et al. 1989), with severe effects on the archaeology.

Agriculture

Fulfilling the goals of the Jazira Project, agriculture has become more intensive and more widespread, made possible by a significant increase in irrigation, and tractors. While the total amount of agricultural area has not really increased since the 1960s, the number of tractors has increased significantly (see Figure 9.13). In 1961 there were only 3300 but by 2000 there

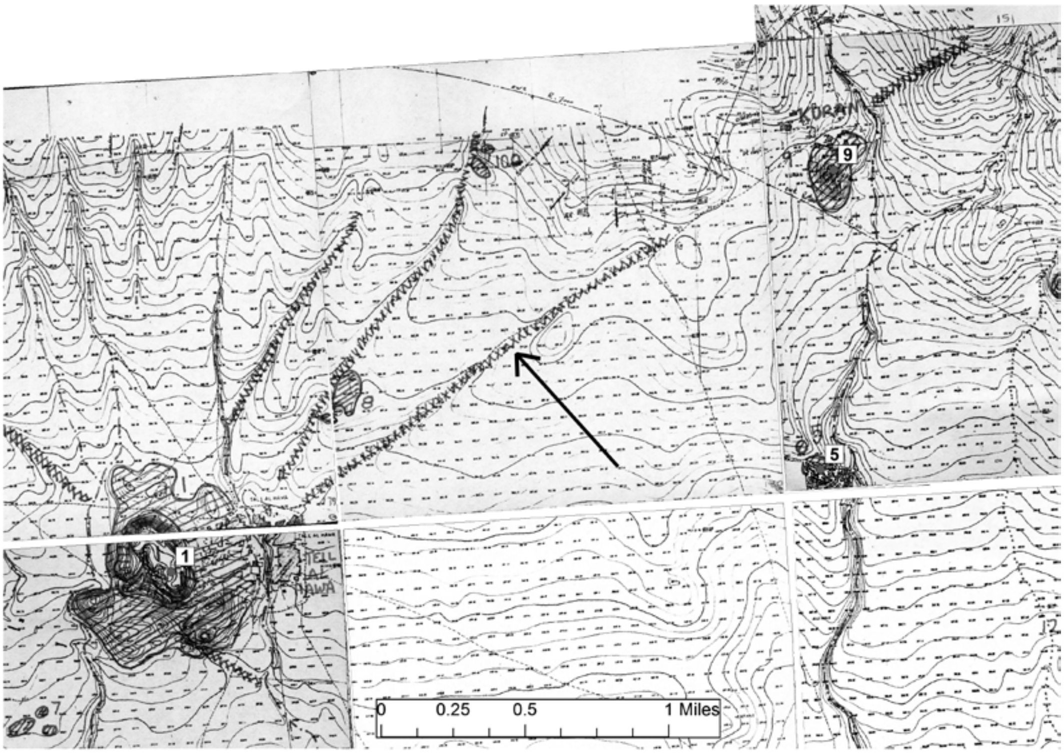

Figure 9.11. The hollow way segment between Site 1 and Site 9 on the contour map: Hollow ways are marked with cross-hatching. The N–S wadi running through the hollow way past NJS 9 is also visible on the far right: probable wadis are marked.

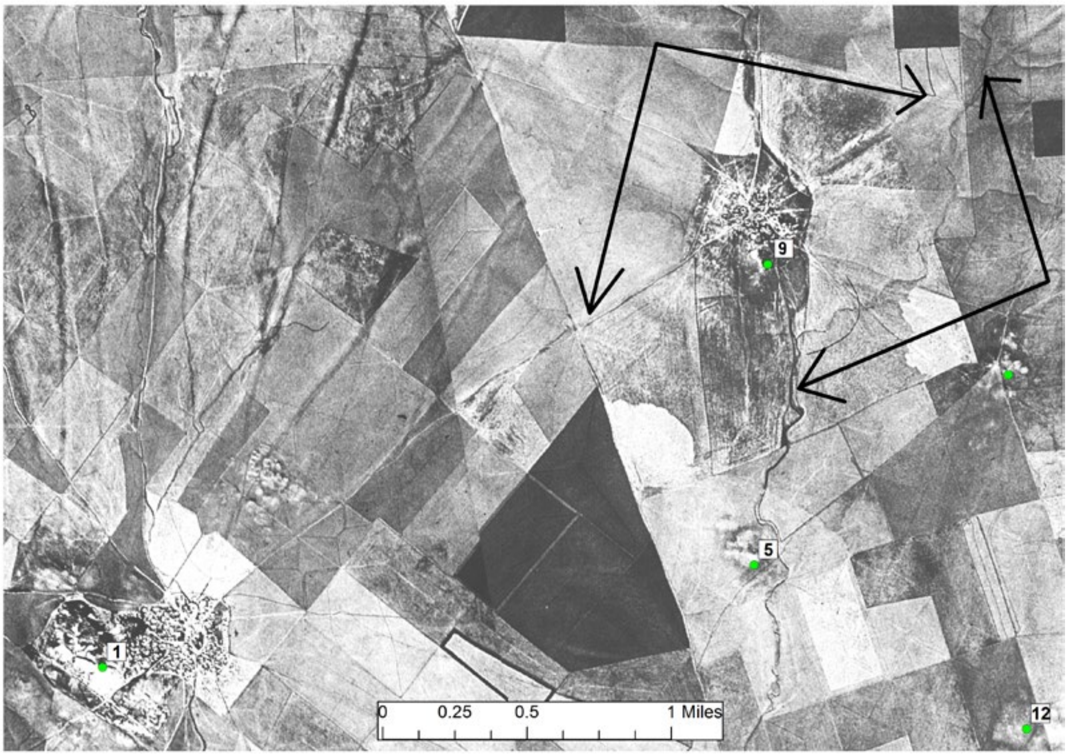

Figure 9.12. The hollow way segment between Site 1 and Site on 1108 CORONA: The top arrows indicate the hollow way. The N–S wadi running through the hollow way past Site 9 is marked with the lower arrows.

were more than 46,000 (FAO Statistics Division 2013). All hollow ways in this area that are not buried under houses, or built over in some way, are in fields — none are in scrubland. Prior to the project, this area had been under tractor plowing for at least 50 years: plowing marks have been visible since the CORONA images were taken. It is often remarked that tillage brings sites to the surface by churning up anthropogenic soils and pottery sherds, but in the case of hollow ways there is nothing to reveal, and tillage will instead slowly destroy subtle (and even major) topographic features (Cunliffe 2013: 57–66; Ur 2010a). Today, double cropping is standard practice, increasing not only the number of times the field is ploughed, but also the amount of time the soil is open to erosion. Natural erosion can cause significant infill that makes it hard to detect the remnants of hollow ways (Wilkinson *et al.* 2010), and this is strongly exacerbated by agriculture. In addition, the small strip fields that marked early agricultural practices are largely gone: most fields are now larger, single crop fields that are easier to use modern machinery on.

Wadis operate under many of the same principles as hollow ways — they are long indented channels that can conduct water and disrupt modern agricultural machinery. When discussing the demise of perennial wadis, Wilkinson and Tucker (1995: 4) remarked: 'It is clear that once flow diminishes below a certain interval, such as one significant flow every two to three years, it will fail to evacuate much of its sediment load. If plowing takes place every year or two on the adjacent terrain, lateral plough-wash will choke the valley floor, and the wadi channel will cease to present an impediment to plowing. As a result, plowing will operate freely across the former wadi bed, thus reinforcing its demise as a hydraulic feature. Such factors clearly operate today with the result that many wadi floors are barely perceptible.'

Many wadis no longer exist, and this programme of intensive (and intensifying) agriculture is almost certainly responsible for the final demise in numerous hollow ways. For example, a section of Route C runs adjacent to Site 20, Site 58, and on to Site 92. The CORONA imagery indicates that a wadi runs parallel. However, the 2004 Digital Globe image available on Google Earth demonstrates that the wadi has been ploughed out, as has most of the hollow way.

Irrigation

In order to achieve the expansion in agriculture, irrigation networks now crisscross the area. In addition to the main, large concrete irrigation channels, a number of smaller irrigation channels connect them, and numerous small dug channels branch off these. Although the deep excavation of the huge channels allowed the discovery and recording of many more sites than would otherwise have been possible (noted in Wilkinson and Tucker 1995), they cause extensive damage to the fragile hollow ways (Cunliffe 2013: 69–72). For example, both Site 29 and the adjacent hollow way were discernable on the SPOT imagery from Google Earth (Figure 9.14), but the creation of the concrete irrigation channel destroyed part of the feature, as well as a section of the site.

Even small dug channels can be destructive. THS 8 is a Halaf site, which 'lay in the middle of a large fallow cotton field, which had eradicated its edges. Because the process of making the irrigation furrows had destroyed the mounding of the site, masked the lighter colour of the anthropogenic soils and reduced sherd visibility, it is possible that even intensive field walking might have overlooked this site' (Ur 2010a: 44).

When viewed as a proportion of agricultural land, the increase in irrigated land is clear, with worrying implications for the archaeological resource. Figures from the Food and Agriculture Organisation (FAO) estimate the total agricultural area in Iraq has remained more or less the same. As shown in Figure 9.13, the total area equipped for irrigation, on the other hand, has steadily increased from 2.9% of the land in 1961 to 8.1% in 2011 (14% of agricultural land to 43% of it — almost half!) (FAO Statistics Division 2013). This is perhaps due to the steady decline in the levels of the Euphrates and the Tigris and increasing pressure on dropping groundwater. In addition, a severe drought hit the Middle East between 2007–2009 (IRIN 2009; Trigo et al. 2010), putting further pressure on limited water supplies; Northern Iraq was particularly badly affected. This increasing intensity in irrigation poses a serious threat to sites and features.

Bulldozing

Supporting the move away from strip fields to large, mechanically plowed, irrigated fields, large sections of the region have been bulldozed. In particular, gravity fed irrigation systems such as this need flat surfaces, so a large number of the sites are now flattened. While hollow ways may become collateral damage, often their shallow nature protects them. This can be seen at Site 8, adjacent to Route B (Figure 9.15): the site has been bulldozed flat, but the hollow way is still visible.

Development

Of course, the increasing agriculture requires people, visible in the concurrently increasing development. This also poses a clear threat to sites (for details of the damage done by development, see Davies 1957; Huisman 2012; Williams et al. 2007). Using GIS, settlements within a 4 km radius of the hollow ways were examined. They have increased in number and in size by 53%, from

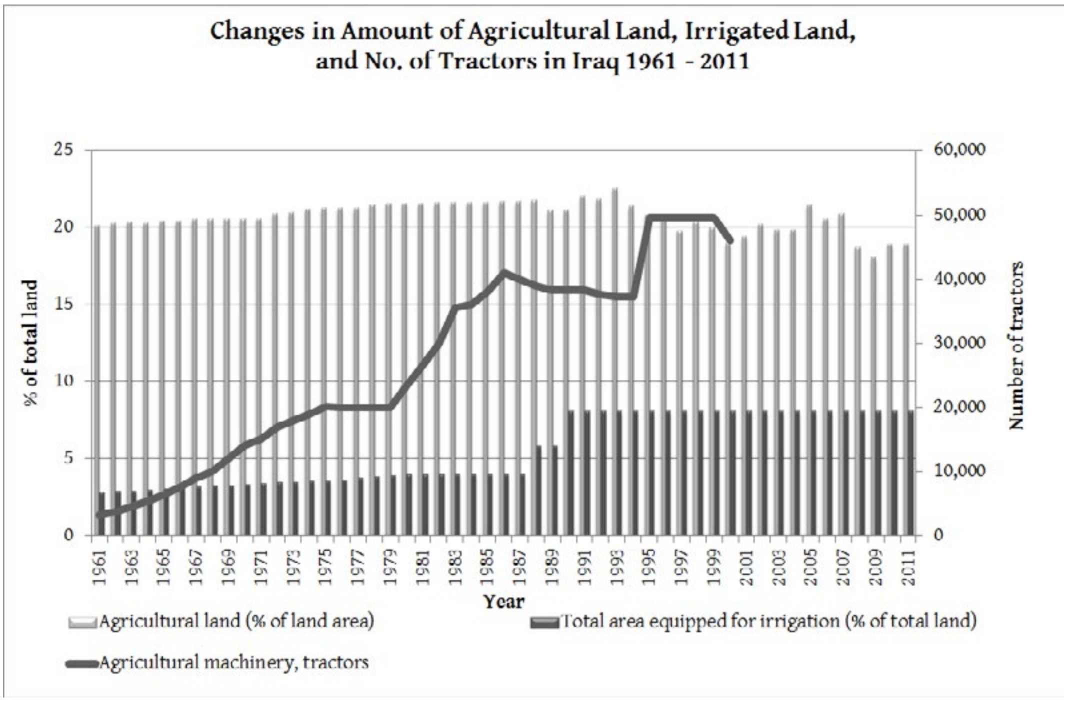

Figure 9.13. Changes in the amount of agricultural land, irrigated land, and the number of tractors between 1961–2011 (FAO Statistics Division 2013).

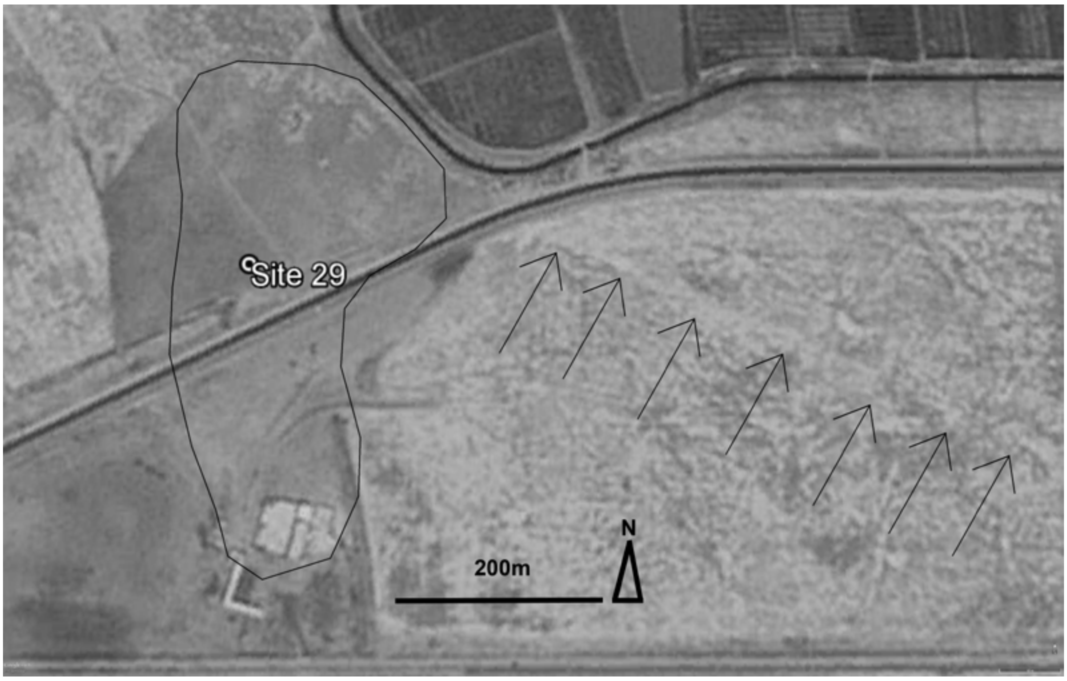

Figure 9.14. Line of the hollow way to the east of Site 29 on the SPOT mosaic available on Google Earth.

Figure 9.15. Route B and Site 8 on 2010 Digital Globe image, and 1102 CORONA (inset bottom right). The inset shows the site in 1967, compared to its appearance after bulldozing. However, Route B is visible on both images.

19 settlements covering 478 hectares on CORONA, to 21 settlements covering 1017 hectares in 2010 (as mapped on Google Earth).

Three settlements went out of use and were turned to fields. Twelve of the examined settlements are on or surround Ninevite V sites, and two are on later settlements. This does not include small single farmsteads, which are extremely numerous.

When examined on early CORONA and aerial photographs, all three routes were outside settlements with the exception of the parts of Route B, which passed through Tell al Hawa, and the parts of Route C that passed through Site 93. Five percent of Route A is now covered, 17% of Route B, and 8% of Route C.

As hollow ways are (today) very shallow features, their traces will have been completely destroyed. An example of the largest settlement increase can be seen at Tell al-Hawa (Figure 9.16), where, in 1967, approximately 700 m of Route B had been destroyed by the village. Examination of Digital Globe imagery from 2010 suggests that circa 1250 m of Route B has been covered by development and destroyed, and circa 600 m of Route A.

Roads

Several hollow ways have also been damaged by roads. On the CORONA imagery, the area is covered in small tracks, identifiable by their higher reflectance/white upcast. As the occupation intensity of the area has increased, while some have fallen out of use, many tracks have been gravelled and then, over the last decade, paved. Whilst there is evidence (albeit not from Iraq) that even these simple, uncovered tracks can damage and erode sites (Kincey and Challis 2010), it is the paved roads that are the greatest threat. Upstanding features are flattened and the topsoil is stripped, before the soil is compacted and asphalt, containing harmful chemicals that can leach into archaeological layers, is applied (Davis et al. 2004). For particularly large roads, foundations are also dug. While small roads at least are not necessarily that damaging to hollow ways, road building removes the two main signs that enable their identification on imagery: increased moisture retention and increased vegetation.

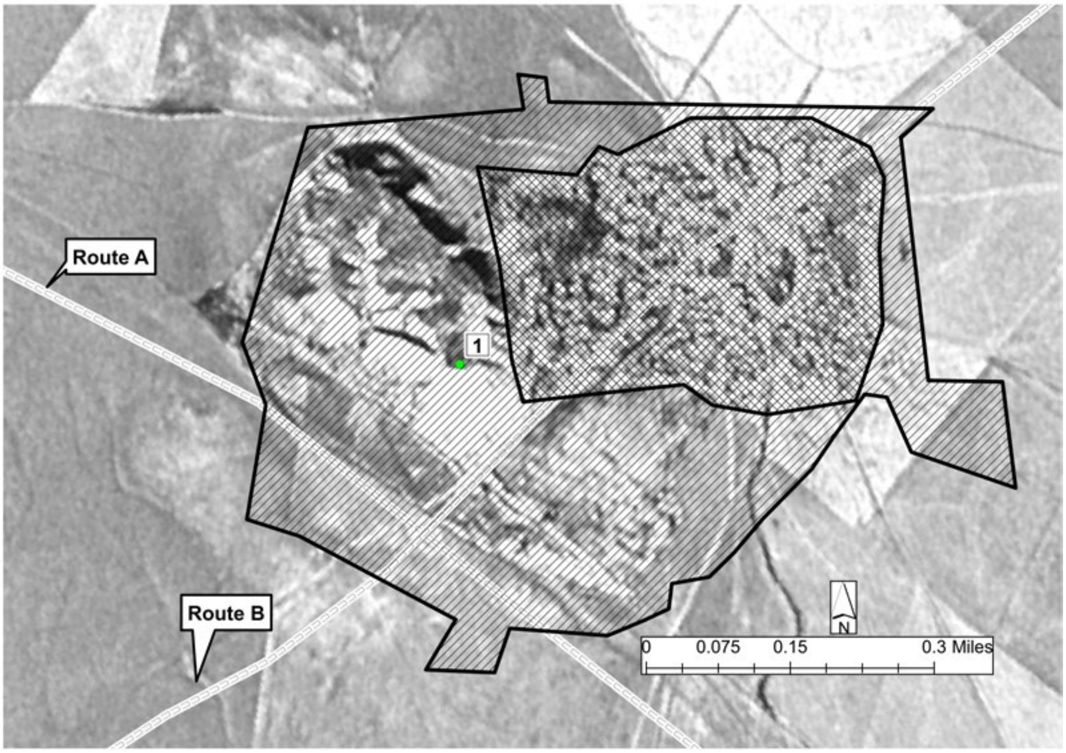

Figure 9.16. The increase in development at (and on) Tell al-Hawa, NJS 1. The lines indicate Routes A and B passed the tell. The cross-hatched area is the size of the adjacent village on 1108 CORONA (1969). The single hatched area is the size of the modern village on the lower town, surrounding the tell. Considerably more of the hollow ways are now covered and destroyed.

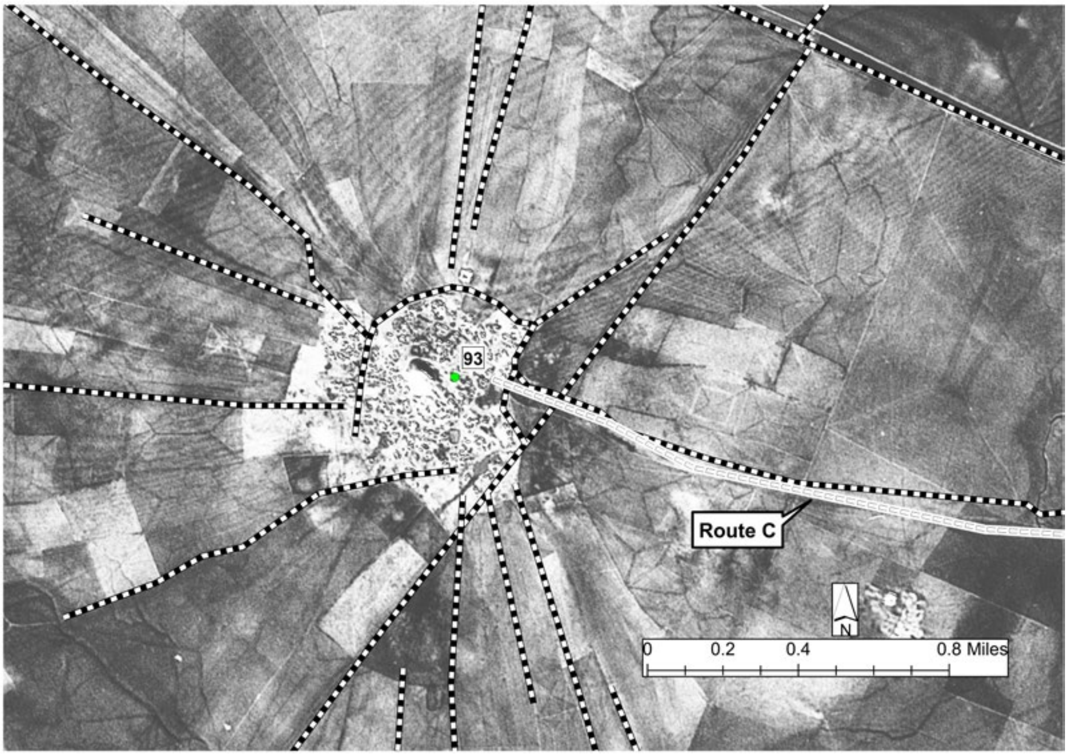

Figure 9.17. Radial roads and tracks surrounding the modern (1960s) town around Site 93 on Route C. These are mapped from all three CORONA images, but displayed here on 1108 CORONA. Route C is indicated running east–west in the right of the picture, paralleling one of the tracks.

Figure 9.18. Modern routes and roads surrounding the modern town around Site 93 on Route C. These are mapped from 2010 Digital Globe imagery on Google Earth. Route C is indicated running east–west in the right of the picture.

In some regions, hollow ways have been destroyed by new roads that mirror the old hollow-way systems. In the North Jazira, at least, the irrigation system has worked to the benefit of the hollow ways. Site 93, visible on the 1102 mission CORONA (1967) in Figure 9.17, is surrounded by a recent settlement even in 1967. In many respects, access to the strip fields surrounding the settlement follows the old radial patterns known from ancient settlements. The more recent modern roads and tracks, however, are constrained by the irrigation channels, with the result that many routes are circuitous and complicated. These routes are almost never direct, or even short, leaving the hollow ways alone (Figure 9.18).

The future: population projections

This brief examination has found extensive evidence of the damage to the ancient routes caused by increasing occupation intensity. The population continued to increase from the early resettlement plans until 2013, when this study was conducted. According to the TAVO Atlas (Mittmann and Schmitt 2001: Map A VIII 3 — Middle East Population Density), by 1978 the eastern Jazira had a settlement density of perhaps 2 to 5 inhabitants per km^2, increasing westward to between 31–100 inhabitants per km^2 in the Khabur Basin. By the mid-1980s, the North Jazira plain had a sprinkling of villages, and in 1995, including the nearby villages of Rabi'ah and Uwaynat, the population of the survey area was approximately 6000 people. World Bank Indicators (2013) suggested Iraq's total population density has increased constantly, reaching 73.1 people per km^2 in 2011, and indications at the time were that the population is still increasing, unlike countries like Syria, whose (pre-conflict) population was decreasing. The rural population made up approximately only one-third of the total population: as in other countries, this has dropped considerably since the 1960s, when 57% of people lived in rural areas. Although there were fewer people there in 2013, rural population growth was increasing far more than urban population growth, putting increased pressure on the limited agricultural land available. In areas such as the Jazira, that land is being used more intensively, reflecting the increasing population density. 2014 however saw heavy fighting in the area, after the so-called 'Islamic State' militants captured the Eski Mosul Dam, leading to heavy fighting to recapture it. In November 2017, BBC news reported that after significant defeats elsewhere, many of the remaining militants fled to the Jazira, where national armed forces pursed them. It remains to be seen what effect the fighting has on the population of the area. Evidence from other conflicts indicates that rural populations, when displaced by conflict, often flee to urban areas, and do not return.[6]

Conclusion

This study has demonstrated that many factors have contributed to the formation and demise of hollow ways in the North Jazira. Building on the geomorphological formation pattern established by Wilkinson et al. (2010), and the route analysis published by de Gruchy (2016; 2017), this paper sought to assess what factors contributed to hollow way formation, and preservation, taking as its start point the fact that physical variables (easiest, fastest, and shortest) did not seem to determine how people moved through the landscape. In addition, we noted that hollow ways formed between settlements that were so close that travellers would have no physical need (such as rest) to stop at each one. Using new methods tested here on three long-distance Ninevite V routes (A, B, and C), it has been possible to consider new theories about why people moved as they did through ancient landscapes and begin to examine the social dimension.

Our results suggest that site size plays a key role: travellers along long-distance routes did not need to seek permission from every local headman (of sites 3 ha and under), but only from chiefs located in centres (>4 ha). This in turn reveals new facets of social organisation: despite a hierarchal social structure, only those of a certain level of importance were perhaps allowed to make decisions about territories, and to grant travel permission. In addition, and perhaps worthy of future research, we noted that several small sites, which would otherwise be unremarkable, were located on these routeways and attained their maximum size during this period, indicating that despite their size they played an active role in the Ninevite V socio-economic network.

In addition, the Thiessen polygon model seemed to tentatively predict the relationship between hollow ways and centres of the Ninevite V Period, suggesting that some of the segments identified belonged to a different period, and that Route C ran along a different path. The model also accurately predicted the location of previously unidentified hollow ways, which were then identified on satellite imagery. Although we could not fully confirm our results due to modern damage in the area, if correct, this would be the first time (barring Wilkinson's excavation) that hollow ways have been tentatively dated by anything other than association with dated sites.

This study has analysed the first of many cultural variables that may have influenced travel, and therefore route formation. In the future, additional cultural variables will be assessed both for this region and beyond, further enhancing our understanding of movement and its relationship to social structures in this period. Recent work by de Gruchy (2017) reassessed Wilkinson and Tucker's (1995) Ninevite V dating using new survey data from the region (Ur 2010), and re-applied nested Thiessen polygons to a larger subset of data. Space constraints mean it is not possible to give the study the attention it deserves here, but two aspects should be noted. The first is that in general our results remain valid, but in addition, the results created a boundary (not located at the survey boundaries) that appears to correlate to two different settlement systems (Figure 9.19). This has important implications for the extent of power during the early 3rd millennium BC, which suggests an earlier date for polities than currently established.

However, it is an inescapable fact that the routes we are analysing are a biased sample. Some hollow ways have been destroyed before they could ever have been documented, as have parts or all of some sites. Of the three routes examined, the best preserved (Route A) had only 68% remaining on the CORONA imagery, and only 58% visible on Google Earth today. Of the worst preserved, only 17% of Route C has survived. By the time Ur recorded the network on the CORONA imagery, almost half was already gone, and today Google Earth suggests that figure has risen, with two-thirds now destroyed, with all due loss of potential information, and the figures are similar (48% preserved, 52% destroyed) for the hollow ways of the North Jazira located in neighbouring Syria (de Gruchy forthcoming). Nonetheless, just as the destruction of sites does not always prevent examination of larger-scale settlement patterns, travel networks can still be inferred, even from fragmentary remains. Still, the incomplete preservation of routes hinders our understanding of the development and use of route networks, as noted in our analysis of the potential path of Route C, where suspected segments can never be confirmed, hindering our understanding of travel and the cultural and socio-economic networks it embodies. Some hollow ways may have continued to be used long after the Ninevite V Period, potentially even through to the present day. For example, the road between Sites 14 and 23 lies precisely where we would expect the find a hollow way that would complete Route B. Unfortunately, the building of the modern road will have destroyed any traces of the hollow way, so the true extent of the route,

[6] See accounts from Stolac in Hadzimuhamedovic (2015), and from Gernika in Viejo-Rose (2013).

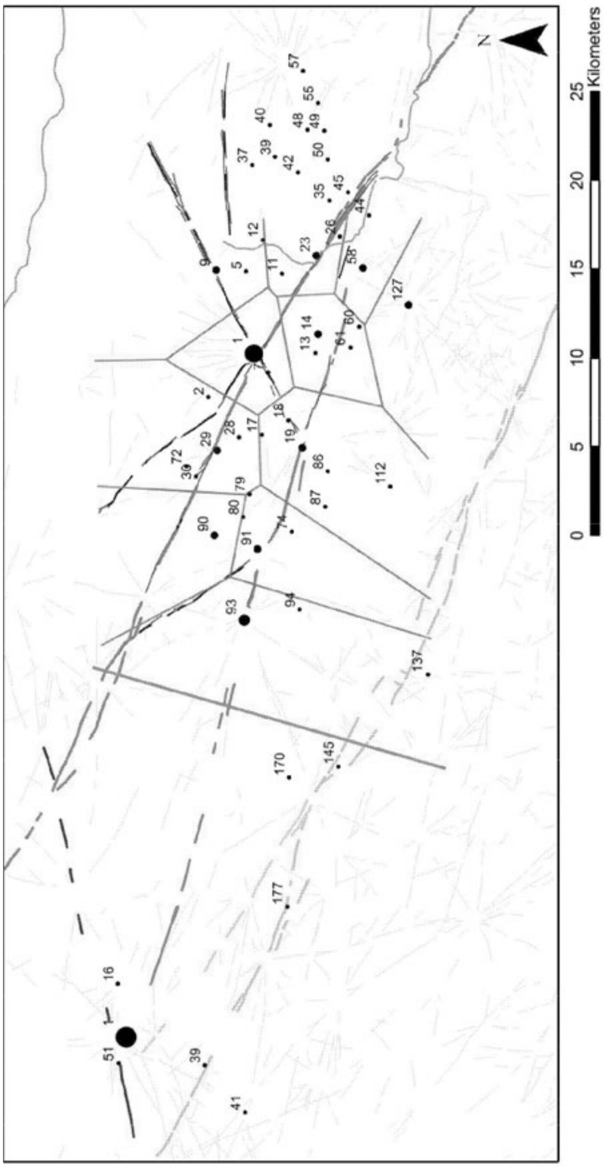

Figure 9.19. A reassessment of the area, including updated periodisation of sites in the North Jazira Survey area and the addition of Ninevite V Period sites from the adjacent Hamoukar Survey, suggests that Tell al-Hawa (the largest site in the right half of the map) and Tell Hamoukar (the largest site in the left half of the map) may have been at the centre of two adjacent polities with differing settlement systems as indicated by the Thiessen polygons in red (figure reproduced from de Gruchy 2017: fig. 9.38).

and the implications for historic travellers, can never be known for certain.

That being said, the levels of preservation over the last 5000 years are remarkable, given that many of the destructive factors examined were present for considerable periods. Yet, it must be remembered that many of the periods when agriculture, for example, was at its peak are the same periods when there were many people who may have continued to frequent these tracks in much the same way as settlements continued to cluster around ancient loci. A review of the routes on CORONA imagery demonstrated that tracks can form quickly, and suggests that some hollow ways were potentially reused in the 1960s, evidenced by a highly reflective surface, appearing only in some seasons. Access to additional CORONA imagery has also demonstrated the presence of new sections of existing routes, and a wider study has the potential to shed further light on these routes. However, the brief re-examination of the CORONA imagery also highlighted that some route segments visible on the 1955 aerial photographs used in the NJS survey were already gone on the CORONA images. The rate of attrition today is considerably higher.

There is no discernable reason why some route segments have survived whilst others are lost. Original size/depth are almost certainly factors, although none of the reviewed routes were considered 'broad', which would indicate a relationship to greater use. Hollow ways between sites that were the most frequently occupied (theoretically then leading to greater use, deepening the hollow ways more) were in fact the most poorly preserved. Many of the routes deep enough to have been visible on contour maps are those that survive best today, yet others left no such obviously deep trace but can still be seen (for example, the segment between Sites 93 and 91). Water erosion plays a part in deepening hollow ways, contributing to survival, but it is not the sole, or even main, factor: that accolade goes to human endeavor. Increasing agriculture, the irrigation programme that necessitated the original rescue survey, urban development and the creation of modern roads, all supported by bulldozing, have all played a part. Although population pressure poses a serious threat to sites and to the more fragile off-site remains, such as hollow ways, we stress that the needs of the modern population, particularly in light of the devastating conflict, must come first, but hope that management planning may offset any necessary damage.

Offering some slight hope, seasonality clearly also plays a factor: some features are clearer due to the increased moisture levels on the October 2010 DigitalGlobe, which covers only a small part of the survey area, so additional hollow way sections may yet remain. Additionally, subsurface remote sensing techniques continue to develop (for example, Casana 2014), which could identify hollow ways that have been plowed level to the surrounding landscape but still have an underground profile. It is tempting to suggest that this study be repeated as more and better imagery becomes available, but with each year that passes, the likelihood is that more will be lost. It is for this reason that we are grateful for the information available to us from the study of older aerial photographs, satellite images, and historic maps, which provide windows into the landscape before the intensive modernisation and ensuing destruction we see today.

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